Saskatchewan Agriculture, Food and Rural Revitalization

FARM Facts

Sulphur fertilization in crop production

Generally, plants require about a tenth as much sulphur (S) as nitrogen (N), but sulphur deficiencies restrict plant growth as surely and severely as nitrogen deficiencies. Canola and alfalfa are examples of high sulphur-using crops (Table 1). Sulphur is not mobile in the plant so a continuous supply of sulphur is needed from emergence to crop maturity. A deficiency of sulphur at any stage of growth can result in reduced yields.

For the first half century or more of cultivation, sulphur deficiency was not a concern on most of our soils because a large pool of organic sulphur was made available as organic matter was mineralized. Over time, however, the pool of organic sulphur has declined significantly, mostly due to use by crops, particularly high sulphur-using crops such as canola and alfalfa (Table 1).

Sulphur deficiencies occur throughout Saskatchewan, but particularly:

- for high sulphur-using crops;
- on sandy soils;
- on gray soils in the northern grain belt; and
- on low organic matter soils.

Table 1. Sulphur uptake by crops in lb. sulphur/acre

Crop	Yield/Acre	Grain	Straw	Total uptake	Sulphur uptake (average)
Spring wheat	40 bu	4 - 5	4 - 5	8 - 10	0.2 lb./bushel
Barley	80 bu	6 - 8	6	12 -14	0.16 lb./bushel
Oat	100 bu	4 - 5	8 - 9	12 - 14	0.13 lb./bushel
Rye	55 bu	4 - 5	10 - 12	14 - 17	0.28 lb./bushel
Canola	35 bu	10 - 12	7 - 9	17 - 21	0.54 lb./bushel
Flax	24 bu	5 - 6	7 - 9	12 - 15	0.56 lb./bushel
Pea	50 bu	6 - 7	5 - 7	11 - 14	0.25 lb./bushel
Lentil	30 bu	4 - 5	4 - 5	8 - 10	0.30 lb./bushel
Potatoes	20 tons	11 - 13	5 – 7	16 - 20	0.9 lb./ton
Alfalfa	5 tons	-------	-------	27 - 33	6.0 lb./ton
Grass	3 tons	-------	-------	11 - 14	4.2 lb./ton
Barley silage	4.5 tons	-------	-------	14 - 21	3.9 lb./ton

These are average values. Uptake varies with soil and climatic conditions.
Adopted from "Nutrient Uptake and Removal by Field Crops – Western Canada" by the Canadian Fertilizer Institute.

Sulphur deficiency symptoms

Sulphur is essential for many growth functions in plants including: nitrogen metabolism, enzyme activity, and protein and oil synthesis. Generally, sulphur-deficient plants have short and/or spindly stems and yellowing of the young (top) leaves. With nitrogen deficiency, yellowing affects the older, lower leaves first. Sulphur-deficient canola can also have purpling and upward cupping of young leaves, delayed and prolonged flowering, pale coloured flowers, and fewer, smaller pods.

Sulphur-deficient alfalfa, pea and other legumes may have reduced nitrogen fixation.

For cereals and forage grasses, yellowing of the newly emerging leaves is an indicator of sulphur deficiency.

Baking quality of bread wheat

Adequate levels of sulphur are required for bread wheat production to optimize baking quality. Wheat fields deficient in sulphur require the addition of about 10 lb. of sulphate-sulphur per acre.

Yield

Substantial yield increases can be obtained by applying sulphur fertilizer to crops having sulphur demand that cannot be satisfied by soil sulphur supply (Table 2). Sulphur fertilization may also produce earlier and more uniform maturity and higher oil and protein levels.

How much sulphur fertilizer to apply

Both nitrogen and sulphur are important in plant protein synthesis. The correct balance of nutrients is particularly important for high sulphur-using crops like canola and alfalfa.

Canola takes up nitrogen and sulphur in a ratio of about five to one (for example, 20 lb. S/acre for 100 lb. N/acre) to optimize protein, oil synthesis and yield. Applying high rates of nitrogen without sulphur can lead to a lower yield than if no nitrogen was applied. Note in Table 2 how yield was lowest for the "nitrogen, phosphorus (P), potassium (K), no sulphur" treatment.

Table 2. The effect of sulphate-sulphur on canola and barley seed yield and alfalfa dry matter yield on sulphur-deficient soils

Fertilizer	Canola NW Sask (one site)	Canola NE Sask (average of four sites)*	Barley Northern Alberta (one site)	Alfalfa NE Sask. (average of three years – one site)**
No fertilizer	13 bu./acre	9 bu./acre	33 bu./acre	0.90 tonnes/acre
Nitrogen (N), Phosphorus (P), Potassium (K), [no Sulphur (S) for canola and barley]	12 bu./acre	1 bu./acre	26 bu./acre	1.22 tonnes/acre (with P) 0.85 tonnes/acre (with K)
Nitrogen, Phosphorus, Potassium, Sulphur	32 bu./acre (23 lb. sulphate-S/ac.)	21 bu./acre (13 lb. sulphate-S/ac.) 25 bu./acre (27 lb sulphate-S/ac.)	76 bu./acre (20 lb. sulphate-S/ac.)	2.78 tonnes/acre (with S) 3.19 tonnes/acre (with P, K, S)

* *Source: S. S. Malhi, Agriculture and Agri-Food Canada, Melfort, Saskatchewan.*

** *Source: L. Cowell, A. Johnston, Soils and Crops Workshop 2001. The rate of sulphur as 50 lb. sulphate-S/ac. applied in the first year. No nitrogen applied with alfalfa.*

Sulphur fertilizers

There are three main types of sulphur fertilizer.

Sulphate-sulphur fertilizers contain sulphur in combination with other nutrients, such as nitrogen or potassium. Sulphate is readily available to growing crops and sulphate-sulphur fertilizers dissolve quickly. The most common sulphate-sulphur fertilizer sold in Saskatchewan is granular ammonium sulphate (20-0-0-24, 21-0-0-24, 19-2-0-22).

Ammonium sulphate can be blended with other granular fertilizers, but care should be taken to ensure the physical nature of the ammonium sulphate will allow the blend to remain uniform.

Potassium sulphate (0-0-50-18 and other formulations) is also available and is well suited to legume crops such as alfalfa, where both potassium and sulphur are needed but not nitrogen.

There are other fertilizer products containing some sulphate-sulphur, either in a blend or in a manufactured product.

Elemental sulphur is not immediately effective for soils very deficient in sulphur, but may be a useful part of a long-term sulphur fertilizer management plan for soils low in plant-available sulphur.

Elemental sulphur fertilizers (0-0-0-90 to 99) are granular, with 90 to 99 per cent sulphur in the elemental form. Elemental sulphur cannot be directly used by plants. It must first be converted to sulphate-sulphur (SO_4^{-2}-S) by soil microorganisms.

In general, the finer the particle size and more thoroughly it has been mixed in the soil, the faster it will convert to sulphate. Broadcast applications of elemental sulphur tend to convert to plant-available sulphate more rapidly than banded applications. When broadcast on the surface the freeze-thaw and wet-dry cycles help disperse the granules and further reduce the sulphur particle size to allow specific soil microorganisms to convert the elemental sulphur to plant-available sulphate-sulphur. The conversion of elemental sulphur to plant-available sulphate may be very slow when placed as a band in cold, dry soils.

It is difficult to accurately predict the rate of conversion of elemental sulphur to plant-available sulphate as it is sensitive to a variety of soil and environmental conditions. Depending on the product, elemental sulphur should be broadcast applied about two years or more before the crop will need sulphate-sulphur to give time for the conversion to sulphate to occur. Increase in plant-available sulphate should be verified through a soil test.

The slow conversion of elemental sulphur to plant-available sulphate can be an advantage. High rates of elemental sulphur can be applied once every few years to soils that require sulphur for all crops, or to long standing, high sulphur-using crops such as alfalfa and other forage crops.

Elemental sulphur can be blended with some granular fertilizers, but not with ammonium nitrate (34-0-0 or 34.5-0-0-0). Contact your fertilizer dealer for details.

Fertilizers containing sulphur as thiosulphate, such as liquid ammonium thiosulphate (12-0-0-26), must also be oxidized by microbes in the soil to the sulphate form. However, the oxidation is rapid and recommended rates of ammonium thiosulphate can be applied the year sulphate-sulphur is required. Ammonium thiosulphate can be applied before, during or after seeding. However, when applied as foliar or dribble band to a crop, direct contact with plant leaves may cause leaf scorching. Follow manufacturers' instructions for blending.

Animal manure

Animal manures can provide sulphur along with other plant nutrients, but the sulphur content and balance with other nutrients is variable and should be determined through manure anaysis along with soil testing to determine relative requirements. For example, some liquid swine manures have low contents of available sulphur relative to nitrogen, and crop responses to supplemental sulphur fertilizer have been observed on manured soils in field trials where sulphur deficiencies exist.

Irrigation water

In Saskatchewan, irrigation water generally supplies more than enough sulphur to meet the needs of irrigated crops. For example, water from the South Saskatchewan River contains three to five pounds of sulphate-sulphur per acre-inch of irrigation water. Water testing is encouraged.

Time and method of application

Sulphur fertilizer can be applied in a number of ways (see Table 3).

A limited amount of sulphur fertilizer can safely be applied with the seed. The amount depends on seed type (i.e., canola, cereal, etc.), amount and type of other fertilizers, width of and distance between bands, soil type and soil conditions. Safe amounts of ammonium sulphate or ammonium sulphate plus nitrogen fertilizer should follow the guidelines for maximum amounts of seed-placed nitrogen according to the amount of nitrogen added as seed-placed ammonium sulphate plus the nitrogen added in any other seed placed nitrogen fertilizer. *See Guidelines for safe rates of fertilizer applied with the seed.*

Like nitrate-nitrogen, sulphate-sulphur is very mobile so top dressed sulphate-sulphur fertilizer will be moved into the soil by rain. Unlike nitrogen, top dressed sulphur fertilizer is not subject to volatilization losses. On soils low in sulphur, application of sulphate-sulphur fertilizer can be effective up to the first flower stage of canola (or mustard), though the earlier the sulphur is top-dressed the more effective it will be (Table 4).

Due to its mobility, sulphate can also be leached below the rooting zone by high amounts of rain on sandy soils. Furthermore, sulphur, like nitrogen, can be immobilized (tied up) for a period during straw decomposition.

Table 3. Timing of various sulphur application methods for grain crops according to sulphur fertilizer form

Application method	Granular ammonium sulphate (20 or 21-0-0-24) (19-2-0-22)	Granular elemental sulphur (0-0-0-90 to 99)	Liquid ammonium thiosulphate (12-0-0-26)
Broadcast or dribble banded (liquid)	Before and after seeding	About two years or more before the plants need it.*	Before crop emergence
Broadcast and incorporated	Before seeding	About two years or more before the plants need it.*	Before seeding
Banded	Before seeding		Before seeding
Seed placed	Limited amount during seeding		Limited amount during seeding
Banded near the seed	During seeding		During seeding

** Conversion to sulphate depends on soil and climatic conditions.*

Table 4. Relative effectiveness of sulphate-sulphur fertilizer applied at different growth stages on seed yield of canola (average of six sites)

	Seed yield with applied sulfate-sulphur (bu./acre)	
Fertilizer treatment	13 lb./acre	27 lb./acre
Nitrogen* alone	3	
Nitrogen + pre-seed incorporated sulphur	19	22
Nitrogen + side-banded sulphur at seeding	19	22
Nitrogen + seedrow placed sulphur	19	21
Nitrogen + surface broadcast sulphur at bolting	15	17
Nitrogen + foliar sprayed sulphur at bolting	16	18
Nitrogen + surface broadcast sulphur at flowering	12	14
Nitrogen + foliar sprayed sulphur at flowering	14	15

** Refers to 107 lb. nitrogen/acre, applied at seeding.*

Source: S. S. Malhi, Agriculture and Agri-Food Canada, Melfort, Saskatchewan.

Using sulphur fertilizer to lower soil pH in Saskatchewan soils

Applying high rates of sulphur fertilizers to lower pH of the soil is not highly effective. This practice is usually done to try to make iron, zinc or other nutrients more available to some horticulture crops. Additions of high amounts of sulphur fertilizers can also increase the amount of soluble salts (sulphates) in the soil causing the salinity levels to increase. The increase in soil salinity can reduce yields of sensitive crops. Applying the appropriate fertilizer to address the nutrient deficiency is more effective under Saskatchewan soil and climatic conditions.

This bulletin was revised by the Saskatchewan Soil Fertility Subcouncil.

For more information, contact your Extension Agrologist.

Conversions from imperial to metric:

lb./acre x 1.12 = kg/ha
tons/acre x 2.24 = tonnes/ha
lb. x 0.45 = kg
ton x 0.91 = tonne

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